

Observations on the ecology and habitat of *Carcharodus stauderi* REVERDIN, 1913 on the Greek island of Kalymnos (Lepidoptera: HesperIIDae)

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Abstract: During a journey to the island of Kalymnos (Aegean Sea, Greece), the authors studied ecology and behaviour of *Carcharodus stauderi* REVERDIN, 1913 in the field. Imagines and first instars were found in considerable numbers. *Ballota acetabulosa* (L.) BENTH. (Lamiaceae) was confirmed as hostplant. At least three different species of parasitoids were obtained from bred caterpillars and pupae. *C. stauderi* uses heavily grazed areas as habitats and can be fairly common in such places.

Keywords: Host plant, Greece, *Ballota acetabulosa*

Beobachtungen zu Ökologie und Lebensraum von *Carcharodus stauderi* REVERDIN, 1913 auf der Ägäisinsel Kalymnos (Lepidoptera: HesperIIDae)

Zusammenfassung: Während einer Reise auf die griechische Ägäisinsel Kalymnos untersuchten die Autoren Ökologie und Verhalten der Dickkopffalterart *Carcharodus stauderi* REVERDIN, 1913 im Freiland. Falter, Larven und Puppen kamen in beträchtlicher Anzahl vor, und *Ballota acetabulosa* (L.) BENTH. (Lamiaceae) dient als Eiablage- und Raupen-nahrungspflanze. Mindestens drei verschiedene Arten von Parasitoiden schlüpften aus Larven und Puppen. *C. stauderi* nutzt intensiv beweidete Flächen als Lebensraum und kann an solchen Orten auf Kalymnos häufig auftreten.

Introduction

While the faunistics and ecology of the majority of the *Carcharodus* species in Greece are now rather well documented (LAFRANCHIS 2003, PAMPERIS 2009), *C. stauderi* remained somewhat of an exception caused by lack of studies. This is certainly due to its very limited distribution area in Greece restricted to some of the Dodecanese islands.

Carcharodus stauderi inhabits an area from Turkey and the Levant to Iran and also the Mediterranean regions of Northern Africa (TENNET 1996, TOLMAN & LEWINGTON 1997, TSHIKOLOVETS 2011). J.-L. REVERDIN (1913) described the species – exactly a century ago – based on specimens collected by Hermann STAUDER in northern Algeria.

Within Europe, *C. stauderi* occurs only in Greece where it so far has been found on the following Dodecanese islands: Leros, Kalymnos, Kos, Simi, Nissiros, Tilos and Rhodes, and it is also present on Kastellorizo (OLIVIER 1993, 1994, 1996, 1997, 2000, OLIVIER & DE PRINS 1996, KUDRNA et al. 2011, CUVELIER & MØLGAARD 2012, COUTSIS & GHAVALAS 2013; see map in Fig. 11). Records from Samos and Lesbos are considered doubtful (PAMPERIS 2009). In adjacent areas of Turkey, *C. stauderi* has been

found in Kesre, İzmir province (HESSELBARTH et al. 1995), and Fethiye, Muğla province (ERGÜN 2013).

Intrigued by the scarceness of documented ecological observations on *C. stauderi* in Greece the first author planned a field trip to study the species there as part of his *Carcharodus* research project. After literature analysis, especially of the valuable publications of A. OLIVIER (1993, 1994, 1996, 1997, 2000 and OLIVIER & DE PRINS 1996), the island of Kalymnos was selected as investigation area due to practical reasons: its relatively easy accessibility and the fact that the second author was already quite familiar with this island from previous visits starting in 1989. Our visit to the island lasted from 31. v. to 7. vi. 2012.

The spelling of geographical names follows established transliteration from the Greek to the Latin alphabet in English texts. Other versions are also in use (e.g. Kálimnos instead of Kalymnos).

The focus of the enquiry was as follows:

- Gathering data on the distribution of *C. stauderi* on the island.
- Clarification of the ecology and behaviour of the species, especially which larval hostplant(s) are used.
- Identification of potential threats of the population(s).

The island of Kalymnos

The Greek island of Kalymnos is situated in the eastern Aegean Sea between Leros (2 km to the north) and Kos (12 km to the south) (WIKIPEDIA 2013, SGAIP-MMAIF 2013). It is part of the Dodecanese group (“twelve islands”). The distance to Bodrum peninsula in Turkey is 17 km to the east. Kalymnos has an area of 110 km², and is 21 km long and 13 km wide at its widest point. The community of Kalymnos also includes the inhabited islands Telendos (1 km to the West) and Pserimos (5 km to the East).

Kalymnos is a mountainous island and is composed of three mountain ranges. The highest summit Profitis Ilias has an altitude of 676 m. The eastern valley of Vathis is used agriculturally while the western valley between the island capital Pothia (also called Kalymnos town) and Chorio is nowadays mostly covered by housing developments. It is here that the majority of the 16 000 inhabitants lives. Tourist development occurs mainly along the west coast, especially in places with small, easily accessible beaches. Since about 15 years ago, however,

¹ Third contribution to the knowledge of the genus *Carcharodus* (second contribution: ALBRECHT 2012).



Figs. 1–10: *Carcharodus stauderi*. **Fig. 1:** Fresh ♂, Arginonda, 1. vi. 2012. **Fig. 2:** ♂, Arginonda, 1. vi. 2012. **Fig. 3:** Courtship behaviour, Arginonda, 2. vi. 2012. **Fig. 4:** Copulating pair on *Marrubium vulgare*, Arginonda, 2. vi. 2012. The coloration of the ♂ and ♀ are different, especially on the underside of the hindwings. **Fig. 5:** Habitat with hostplant *Ballota acetabulosa*, Arginonda, 1. vi. 2012.

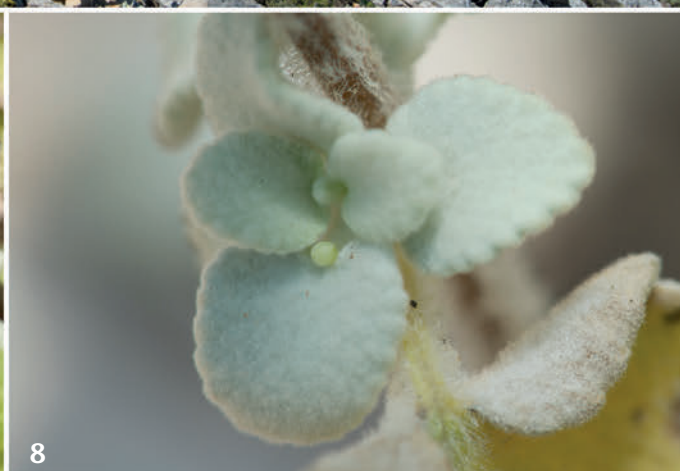


Fig. 6: Habitat with hostplant, Profitis Ilias, 4. vi. 2012. **Fig. 7:** Oviposition on *Ballota acetabulosa*, Arginonnda, 1. vi. 2012. **Fig. 8:** Freshly laid egg on *Ballota acetabulosa*. The leaves were slightly manipulated to reveal the egg. Arginonnda, 1. vi. 2012. **Fig. 9:** 4th instar larva (leaf shelter opened). As all other larvae found during the field trip, this one likewise turned out to be parasitised. Profitis Ilias, 4. vi. 2012. **Fig. 10:** Pupa in opened shelter, Profitis Ilias, 6. vi. 2012.

the island has also become a favorite tourist location for intensive rock-climbing activities.

The climate is typically Mediterranean with dry and hot summers. Rain is very scarce between May and October. Average temperatures fluctuate from 26–28°C in July and 8–14°C in January. The deforested mountains are barren, covered with rocky steppes (Greek: Phrygana; WIKIPEDIA 2011) composed of vegetation dominated by low, spiny shrubs (e.g., *Genista* spp. and *Thymus* [= *Coridothymus*] *capitatus*), which are well adapted to wind and dryness. Being spiny in one way or another, they are also protected against consumption by goats or sheep that have created this type of vegetation by long-term overgrazing.

The villages are surrounded by olive and citrus groves. In Vathis valley vegetables are cultivated both outdoors as well as in greenhouses. Recently, two photovoltaic sites have been installed on two fields. Only one small permanent brook exists on the island, flowing into the sea at Vathis.

OLIVIER (1996) outlines the history of the entomological investigations on Kalymnos. So far, 32 species of butterflies and skippers have been recorded from Kalymnos in the literature, 31 of which were already listed by OLIVIER (1996); PAMPERIS (2009) reported *Leptotes pirithous* (LINNAEUS, 1767) as additional species.

The second author could confirm the following migrating or invasive species during his journeys between 2005 and 2012: *Pelopidas thrax* (HÜBNER, [1821]), *Leptotes pirithous*, *Cacyreus marshalli* BUTLER, 1898, and *Danaus chrysippus* (LINNAEUS, 1758) (unpublished data). The invasive lycaenid *Cacyreus marshalli* has started colonizing the Greek islands and is found on Kalymnos at least since 2011 (KISSLING 2012). The presence of *Carcharodus orientalis* REVERDIN, 1913 on Kalymnos is doubtful (see below).

Results

Distribution and habitats of *C. stauderi* on Kalymnos

According to OLIVIER (1996), *C. stauderi* had been found just 20 years before our journey at Arginonda and east of Kalymnos town. Both places mentioned were visited successfully:

- Arginonda: From the south-eastern edge of the village to the neighbouring hills (1.–2. vi. 2012).
- Along main road 4 km east of Kalymnos town: In a gully that stretches from the hills eastwards to a small bay (3. vi. 2012).

Moreover the species was found at three new sites during the trip (Fig. 11):

- The hill between Panormos and Myrties: a rather small population (5. vi. 2012), including one specimen at the Platy Gialos beach near Panormos (6. vi. 2012).
- Profitis Ilias mountain from Chorio to the summit and probably also neighbouring areas: A very big popula-

tion of *C. stauderi* inhabits this vast space (4. & 6. vi. 2012).

- At the north-eastern end of the Vathis valley where the main road turns east and starts climbing the hill (place with Aghios Nikolaos chapel and prehistoric caves): a medium sized population (3. vi. 2012).

The habitats are dry, rocky places with sparse vegetation, mostly hillslopes (Figs. 5, 6). In some other areas – which were searched only very superficially near the roads mostly from the car – no hostplants and therefore no specimens of *C. stauderi* were observed, e.g. east of Arginonda along the road to Vathis until it reaches the highest point of the pass.

Altitudinal range: Imagines of *C. stauderi* were found from sea level (Panormos, beach of Platy Gialos, 6. vi. 2012) virtually to the highest point of the island, i.e., the summit of Profitis Ilias near the chapel. The hostplant was very common over the whole mountain. Not only the skippers were flying near the summit but also first instar larvae were observed.

Hostplant

Immediately after entering the habitat of *C. stauderi* for the first time at Arginonda a Lamiaceae plant was found in large numbers. It was obvious that the skippers were quite interested in this plant. Little later, oviposition was observed and also typical hesperid caterpillars were found in leaf shelters. The plant was determined as *Ballota acetabulosa* (L.) BENTH. (Lamiaceae) using LAFRANCHIS & SFIKAS (2009). Based upon photographs, Tristan LAFRANCHIS (pers. comm.) later confirmed this determination. During our investigations many dozens of caterpillars and pupae of *C. stauderi* were detected on this plant. Therefore, it is doubtless that this plant species is at least the most important – if not the only – hostplant of *C. stauderi* on Kalymnos.

Near Arginonda we also found a larger number of *Marubium vulgare* plants at the edge of the village. We searched for first instars on these plants, but without finding any caterpillars or pupae of *C. stauderi*.

Behaviour

Imagines: Nectaring was observed repeatedly on *Ballota acetabulosa*. In several cases freshly hatched ♀♀ were found on their hostplants in the morning. ♂♂ were exhibiting typical perching behaviour, often sitting on *Ballota* plants or other prominent parts of the vegetation (Figs. 1, 2). During courtship that could be observed only once, the ♂ was chasing the ♀ for about 10 s before copulation took place (Figs. 3, 4). Although not documented in detail it seemed that a dedicated courtship phase was missing. This observation deviates from *C. floccifera* (ZELLER, 1847) that can express intense and sometimes long-lasting courtship behaviour. However, more observations are necessary for *C. stauderi*. Copulation duration was about one hour, which is quite similar

to *C. floccifera* as reported by ALBRECHT (1999: 135). Oviposition was observed several times (Fig. 7). The light green eggs were laid on the upper side of fresh small leaves of *B. acetabulosa*. They are difficult to detect, as they blend well with the leaves of the hostplant (Fig. 8).

First instars: As usual in HesperIIDae, caterpillars and pupae of *C. stauderi* live hidden in “tents” that are made of either one hostplant leaf with spun edges, or up to three such leaves that are spun together (Figs. 9, 10). Judging, however, from the enormously high parasitisation rate in larvae and pupae, it appears that this defense strategy does not work sufficiently well against parasitoids (see below).

Phenology: During the time of the trip many of the skippers were quite fresh, some even freshly hatched. All immature stages – eggs, larvae (4th and 5th instar only), and pupae – were found simultaneously.

Predators and parasitoids

Predators: Only one observation. A dead imago of *C. stauderi* was found in the web of an araneid spider on Profitis Ilias. Large robber flies (Asilidae, Diptera) were also quite common but we did not notice that one of them ever caught *C. stauderi*.

It is obvious that parasitoids play the most important role in controlling the populations of *C. stauderi*. However, only preliminary results can be presented here. Some of the pupae that were collected and all of the caterpillars (about 60) turned out to be parasitised. So far, three different species of parasitoids were identified (determinations by Mark SHAW, based on photographs):

- A black ichneumonid wasp (*Hyposoter* or *Sinophorus* sp.) whose larva lives singly in the caterpillar and usually leaves the host during the 4th instar and pupates outside in a cocoon.
- Gregarious *Cotesia* sp. braconids that come out of the 5th instar caterpillar and pupate outside in a cocoon.
- A black and yellow wasp (*Brachymeria* sp., Chalcididae) whose larva pupates inside the skipper's pupa and that emerges directly from it as an imago (probably here the fresh pupa is being parasitised, M. SHAW, pers. comm.).

Some other remarkable butterflies

Carcharodus alceae (ESPER, [1780]): One ♂ flew at Argionda, and caterpillars were found at Panormos on *Alcea* sp. in a garden and at a roadside northeast of Vathis on *Malva* sp.

Other interesting butterfly species were *Maniola telmessia* (ZELLER, 1847), which was in many places even more common than *C. stauderi*, *Plebeius loewii* (ZELLER, 1847), which flew in the same habitats, *Pseudochazara anthelea* (HÜBNER, [1824]), and caterpillars of *Melitaea trivia* ([DENIS & SCHIFFERMÜLLER], 1775) on *Verbascum* sp. (the latter two on Profitis Ilias).

Discussion

Distribution and population sizes

While the presence of *C. stauderi* on the neighbouring island of Simi was rather well known (OLIVIER 1994, TSHIKOLOVETS 2011, COUTSIS & ANASTASSÍU 2011), we only had some general information on *C. stauderi* on Kalymnos (OLIVIER 1996). As it turned out, large areas of the island are suitable as habitat for the skipper.

According to our observations the population size of *C. stauderi* is directly linked to the number of available hostplants: On the hill between Panormos and Kamari we found only few *B. acetabulosa*, and also only few specimens of *C. stauderi* were flying around, while plants and skippers virtually were omnipresent on Profitis Ilias.

For Kalymnos, the statement of OLIVIER (1994) can definitely be confirmed that “*C. stauderi ambiguus* seems to be extremely common on the smaller islands of the Dodekánissa, as such was also my experience on Níssiros, Kálimnos and Léros in late May–June 1992”. It is probable that *C. stauderi* can be found in many other places on Kalymnos since its typical habitat covers large parts of the island. However, in those regions where the hostplant is not present, *C. stauderi* will be scarce or missing.

Phenology

Since most of the skippers were still rather fresh, it can be supposed that the flight period of *C. stauderi* on Kalymnos begins in the second half of May. The numerous pupae indicate that the species should fly through most of June and maybe to the beginning of July or later. This remains to be confirmed (during earlier visits in September and October, no specimens of *C. stauderi* could be observed; T. KISSLING, unpublished observations). By the end of May all healthy caterpillars had pupated since all that were left turned out to be parasitised.

All data available show that *C. stauderi* has only one generation on Kalymnos. Therefore we suppose that the caterpillars develop very slowly during the hot and dry summer and autumn, reaching only the third instar before beginning hibernation. The rest of the growth is finished in spring when fresh leaves become available. This remains to be confirmed. When bred in captivity in Switzerland on fresh hostplants (*Balota nigra*), the caterpillars continued to feed and pupated in August with imagines emerging in September.

Entomologists visit the Dodecanese islands usually in spring and early summer or autumn so that observations during summer are scarce. J. COUTSIS and M. MØLGAARD (pers. comm.) both observed *C. stauderi* in June on Simi while it was not recorded yet in late April (J. COUTSIS, pers. comm.). PAMPERIS (2009) mentions May and June as flight period. For Turkey, the species flies in one generation from June to the end of September according to HESSELBARTH et al. (1995). In Lebanon “it flies from May till September in two, possibly three,



Fig. 11: Map of Kalymnos with localities of *C. stauderi*. — Inset: Map of the south-eastern Aegean Sea with islands inhabited by *C. stauderi* highlighted.

broods" (LARSEN 1974). However, detailed observations including the first instars are not available.

Behaviour

Imagines and first instars of *C. stauderi* show many similarities with the other species of the genus. The skippers often fly close to their hostplants and use it as nectar source. Eggs are laid on the upper surface on the leaves (the only known exception among the *Carcharodus* species is *C. lavatherae* which uses the flower calyx, but there are occasional exceptions also in other species, T. LAFRANCHIS, pers. comm.), and the caterpillars live in "tents". Pupation also takes place in this "tent".

Hostplants

TOLMAN & LEWINGTON (1997) mention the following plants: *Marrubium vulgare* (Morocco), *Ballota hirsuta* (Hoggar Mts., South Algeria), *Phlomis floccosa* [sic!] (Egypt), *Phlomis aurea* (on Sinai Peninsula). Unfortunately, TOLMAN & LEWINGTON (1997) do not mention the source(s) of the hostplants but *M. vulgare* is probably from POWELL (1914) while LARSEN (1990) lists *P. aurea* and *P. floccosa*. More field research is necessary to discover the hostplant preferences of *C. stauderi* in different parts of its distribution area.

It is possible that *M. vulgare* (the main hostplant of the closely related species *C. baeticus*) could be used by *C. stauderi* on Kalymnos, although we did not find any caterpillars or pupae on this plant near Arginonda.

It appears surprising that *Ballota acetabulosa* has not been earlier identified as hostplant of *C. stauderi*. Already OLIVIER (1994) mentions that the imagines were "always flying near to patches of an unidentified Lamia-ceae species, its probable laval hostplant, as I also saw females inspecting it with the greatest care". It is rather obvious that this plant must have been *B. acetabulosa* and the "inspections" of the ♀♀ were oviposition behaviour indeed. Also PAMPERIS (2009: 645) figures ♂ and ♀ skippers sitting on *B. acetabulosa*.

Habitat

C. stauderi is certainly the species within the genus that is most resilient against heat and dryness and therefore can colonize habitats from summer-dry Mediterranean areas to half-deserts in northern Africa and on the Sinai Peninsula. It is usually found in rocky or sandy habitats with scattered vegetation that are preferred by the hostplants (Figs. 5, 6). This can be confirmed for Kalymnos where *C. stauderi* lives in places with sparse vegetation in the hills and mountains. Habitat photographs from Tilos and Simi (TSHIKOLOVETS 2011) look quite similar to

Kalymnos. The so-called Phrygana-type habitat is characterized by its rocky nature and the presence of scattered vegetation that consists mainly of spiny plants, together also with the non-spiny larval hostplant. Near villages, *B. acetabulosa* can also be found in Olive groves or in uncultivated areas.

A quite surprising fact is that hostplant and skippers both benefit from intensive grazing since *B. acetabulosa* is one of the few plants that are obviously not eaten by goats and sheep although it does not have spines and even does not taste excessively bitter (according to a self-test carried out by the first author). Maybe the hairy surface of the plant has a protective effect. Therefore, the plant is very common in large areas of Kalymnos (but not everywhere), and this enables *C. stauderi* to develop very large populations. A slightly bewildering fact was that despite a large number of sheep that should exist on the island (reportedly 12 000, www.wikipedia.org) the authors did not see many of them in the field during the visit. It must remain open if grazing is still as intensive as it was in the past but *C. stauderi* was common on the island already twenty years ago.

To summarize our observations: We suppose that *C. stauderi* can be found everywhere on Kalymnos where its hostplant is present. The population size of the plants and the skippers seem to be closely correlated.

Parasitoids

Virtually all collected caterpillars and also a considerable fraction of the pupae turned out to be parasitised by one of at least three species of hymenopteran parasitoids. This indicates that the population of *C. stauderi* on Kalymnos is controlled to a large extent by parasitoids.

While for *C. alceae* already several parasitoids are given (SHAW et al. 2009), parasitoid observations from *C. stauderi* were not known to us so far. A detailed analysis of the substantial material is planned.

Open points

Despite many interesting observations, some questions are still open which should be investigated in more detail in the future.

- Collection of more data on the distribution of *C. stauderi* on Kalymnos and the neighbouring smaller islands.
- Phenology of the species on Kalymnos: Does it really have only one generation per year, and how is the development of the caterpillars during summer and autumn? These questions can only be clarified by fieldwork during the appropriate seasons.
- **Accompanying species:** Is *C. orientalis* really present on Kalymnos? OLIVIER (1996) mentions it from Argionda, but we could not find the species during our journey. The specimen from the coll. OLIVIER that is in the collection of the first author now was re-examined but it is in our opinion more likely to be *C.*

stauderi (based on the first results of genitalia analysis, unpublished data). Since it can be quite difficult to differentiate *C. orientalis* and *C. stauderi* in the field, it would make sense to search for *C. orientalis* later in summer because it has a second generation while *C. stauderi* probably does not. Analysis of genitalia is highly recommendable for a clear distinction of both species. For excellent drawings of the male genitalia see COUTSIS & GHAVALAS (2013). We share definitely the opinion of OLIVIER (1996) that the “*C. orientalis*” specimens collected by O. WETTSTEIN between 2. and 4. VI. 1935 near Pothia (REBEL 1936) indeed were *C. stauderi* since REBEL (1936) refers to the cinnamon-brown colour of the underside of the hindwings, which is a typical feature of female *C. stauderi*. More detailed investigations on this question are planned for the future.

- **Parasitoids:** Gathering of more qualitative and quantitative data on the parasitoids of *C. stauderi*.

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